CONFERENCE OF THE COMMITTEE ON DISARMAMENT

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Destruction and disposal of Canadian stocks of World War II Mustard Agent

Historical background

1. Shortly after the outbreak of the Second World War, many countries, including Canada, produced a supply of chemical warfare agents in anticipation of their possible use during the war in retaliation of enemy gas attacks. Gas warfare was never employed, and while most chemical stocks were destroyed in Canada, some quantities of mustard agent remained in storage.

Present Status

2. In Canada approximately 700 tons of mustard agent in bulk liquid form have been retained since 1942 at the Canadian Defence Research Establishment Suffield, at Ralston, Alberta. This material has been stored in reinforced concrete, lead-lined vaults, and no appreciable degradation of the vaults or the mustard has occurred up to the present time. The mustard was primarily HS (2,2'-dichloro-diethyl sulfide) of approximately 70 per cent purity, with a small stock of a more persistent type of mustard referred to as HT. For many years, Canadian Government policy has been to maintain no offensive capability or weaponry in chemical warfare; consequently the mustard was of no use to the Canadian Forces, and a decision was made several years ago to find a safe, effective, clean and economical method of disposing of it.

Methods for destruction of Mustard

3. A number of possible methods for disposing of the mustard were considered. These included: burning the mustard in open pits (as was done in a number of countries after the Second World War) -- this was environmentally undesirable because of the resultant air pollution; dumping it in the ocean -- this was unacceptable for several reasons, including international agreements on ocean dumping; burning the mustard in an existing or specially designed incinerator and scrubbing or dispersing air pollutants from the exhaust gas stream -- this was technically feasible, but very costly and involving some handling hazards; and chemical processes to convert the mustard to a less hazardous or innocuous form, and disposal of the resultant product in an acceptable manner.

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4. The last approach appeared most promising. In the laboratory, mustard was converted to a solid (dithiane) by reaction with sodium sulfide. The solid was easier to handle and less hazardous, but the process was abandoned because of the cost of the sodium sulfide, the environmental problems of disposing of the large volume of dithiane produced, and the engineering problems of avoiding the trapping of unreacted mustard in the solid end product. Conversion of the mustard by hydrolysis to a relatively harmless liquid was also investigated, along with disposal methods for the liquid product. This approach was successful in the laboratory and pilot-plant scale experiments, and was considered technically feasible for bulk destruction.

5. It was generally known that mustard/water mixtures were non-reactive, since hydrolysis did not occur to any significant degree; yet other measurements indicated that mustard which was dissolved in water reacted quickly, with a reaction time equivalent to a mustard half-life of 8-10 minutes at 25°C. A detailed study of this apparent discrepancy led to the discovery that, with the addition of a base to control pH, elevation of the temperature above ambient, and turbulent mixing, water and mustard would react readily to produce a non-vesicant mixture of salts and thiodiglycol. This process was optimized in laboratory experiments, and in pilot-plant scale batch experiments involving up to 50 gallons of mustard per batch. A number of bases were studied for pH control and calcium hydroxide was chosen as the optimum and least expensive. A plant has been designed and built to hydrolyze up to about 7 tons of mustard per batch under the control of a two-man crew.

6. This plan is now operational, and mustard is being destroyed. Full scale trials have demonstrated that the process is non-hazardous and fully effective in destroying the mustard.

Disposal of Mustard Hydrolysate

7. The hydrolysate produced during experimental destruction of batches of mustard contained water, thiodiglycol, calcium salts (primarily calcium chloride) and some polysulfides. Disposal methods studied for this hydrolysate included: incorporation of the hydrolysate in concrete to form a solid; incorporation in landfill; spreading on soil with natural biodegradation; microbial deterioration in a reaction vessel; and high temperature incineration. While natural biodegradation processes appeared promising, insufficient time was available to optimize and prove the environmental acceptability of the method. Studies were therefore concentrated on thermal destruction processes. Several thousand gallons of hydrolysate were incinerated successfully in an existing high-temperature furnace, which was originally designed to burn DDT (ac

DDT/kerosene solutions) and which included a scrubbing tower. Using natural gas as an auxiliary fuel, the hydrolysate was incinerated, and the resultant gaseous effluents, except for a small quantity of sulfur dioxide, were removed in the scrubbing tower. A smokestack was erected to disperse the remaining sulfur dioxide into the atmosphere so that clean air standards could be met. The scrubbing tower water was neutralized with calcium hydroxide and recirculated.

Final Mustard disposal system

8. In the destruction process which is now underway, the mustard hydrolysis is being carried out in the specially designed remotely controlled facility which has been mounted directly on top of the storage vaults. The reaction of each batch (about 7 tons of mustard) is complete in about six hours. One batch can thus be destroyed in one working day. The process is economical, efficient and non-hazardous.

9. Following laboratory verification of reaction completion, the hydrolysate is drained into an interim storage tank, or directly into trailer-mounted tanks for hauling to the incinerator, which is located approximately one mile from the reactor.

10. At the incinerator, the hydrolysate is pumped under pressure into an atomizing nozzle and dispersed into a natural gas flame. Combustion rates of up to 2½ gallons per minute may be achieved under optimum conditions. Thermal destruction of the hydrolysate at the rate of about 35 tons (mustard equivalent) per week is expected.